CLAIMS

1. A piezoelectric/electrostrictive film type actuator which comprises: a ceramic substrate; and a piezoelectric/electrostrictive device disposed on the ceramic substrate and including a piezoelectric/electrostrictive film and electrode film and which is driven by displacement of the piezoelectric/electrostrictive device,

characterized in that the piezoelectric/electrostrictive device wherein the piezoelectric/electrostrictive film and electrode film are alternately laminated to form the electrode film from an uppermost layer and a lowermost layer possesses a plurality of layers of piezoelectric/electrostrictive films.

2. The piezoelectric/electrostrictive film type actuator according to claim 1, wherein the piezoelectric/electrostrictive device possesses two to four layers of piezoelectric/electrostrictive films.

3. The piezoelectric/electrostrictive film type actuator according to claim 1 or 2, wherein a thickness t_n of an n-th piezoelectric/electrostrictive film from bottom in the piezoelectric/electrostrictive device satisfies the following equation:

$t_n \leq t_{n-1} \times 0.95$.

4. The piezoelectric/electrostrictive film type actuator according to any one of claims 1 to 3, wherein a thickness per layer of the piezoelectric/electrostrictive

film is 30 μm or less.

5. The piezoelectric/electrostrictive film type actuator according to any one of claims 1 to 4, wherein at least one layer of the piezoelectric/electrostrictive films is formed by an electrophoresis deposition method.

6. The piezoelectric/electrostrictive film type actuator according to any one of claims 1 to 5, wherein two or more piezoelectric/electrostrictive devices are arranged on the same ceramic substrate.

7. Thee piezoelectric/electrostrictive film type actuator according to any one of claims 1 to 6 in which a cavity is formed in an internal portion of the ceramic substrate, and is pressurized by deforming a part of a wall thereof with the piezoelectric/electrostrictive device,

wherein the substrate is constituted of a plurality of laminated layers of thin plates.

8. The piezoelectric/electrostrictive film type actuator according to claim 7, wherein the ceramic substrate is constituted of two or three laminated layers of thin plates.

9. The piezoelectric/electrostrictive film type actuator according to claim 7 or 8, wherein a thickness of a thinner portion of the ceramic substrate is 50 μm or less.

10. The piezoelectric/electrostrictive film type actuator according to any one of claims 1 to 9, wherein the ceramic substrate is formed of a material containing any of zirconium oxide, aluminum oxide, magnesium oxide, aluminum

nitride, and silicon nitride as a major component.

11. The piezoelectric/electrostrictive film type actuator according to any one of claims 1 to 9, wherein the ceramic substrate is formed of a material containing either stabilized zirconium oxide or completely stabilized zirconium oxide which is a major component.

12. The piezoelectric/electrostrictive film type actuator according to any one of claims 1 to 11, which is used as an ink pump of a printer head disposed in an ink jet printer.

13. A piezoelectric/electrostrictive film type actuator which comprises a ceramic substrate and a piezoelectric/electrostrictive device disposed on the ceramic substrate and including a piezoelectric/electrostrictive film and electrode film, and said substrate being provided with a cavity being formed in an internal portion thereof and said cavity being pressurized by deforming a part of a wall of the cavity with the piezoelectric/electrostrictive device,

characterized in that the piezoelectric/electrostrictive film type actuator is prepared by a method of: preparing a green sheet laminate including at least one green sheet which is a substrate and one or a plurality of green sheets in which at least one hole portion is formed and sintering the green sheet laminate to obtain a ceramic laminate;

forming an electrode film (A) in the outer surface of the obtained ceramic laminate by a film forming method;

thereafter forming a piezoelectric/electrostrictive film (A) on the electrode film (A) by a film forming method, further forming an electrode film (B) on the piezoelectric/electrostrictive film (A) by the film forming method, and repeating the forming of the piezoelectric/electrostrictive film (A) and electrode film (B) once or a plurality of times;

thereafter forming a piezoelectric/electrostrictive film (B) on the electrode film (B) by the film forming method, and further forming an electrode film (C) on the piezoelectric/electrostrictive film (B) by the film forming method; and

sintering the piezoelectric/electrostrictive film and/or the electrode film predetermined times at an arbitrary timing during a period after the electrode film (A) is formed until the electrode film (C) is formed.

14. The piezoelectric/electrostrictive film type actuator according to claim 13, wherein a thickness t_n of the piezoelectric/electrostrictive film formed n-th time satisfies the following equation:

$$t_n \leq t_{n-1} \times 0.95.$$

15. The piezoelectric/electrostrictive film type actuator according to claim 13 or 14, wherein in the steps of forming and sintering the electrode film (B) at a sintering temperature Tm1 (°C) and forming and sintering the piezoelectric/electrostrictive film (B) at a sintering temperature Tm2 (°C), the following equation is satisfied:

$0 \leq Tm2-Tm1 \leq 300$.

16. The piezoelectric/electrostrictive film type actuator according to any one of claims 13 to 15, wherein the piezoelectric/electrostrictive film and electrode film are subjected to a plurality of film forming methods per layer and formed.

17. The piezoelectric/electrostrictive film type actuator according to any one of claims 13 to 16, wherein as the film forming method, at least one thick film forming method selected from a group consisting of a screen printing method, dipping method, coating method, and electrophoresis deposition method is used.

18. The piezoelectric/electrostrictive film type actuator according to any one of claims 13 to 16, wherein as the film forming method of the piezoelectric/electrostrictive film, the screen printing method is used first time, and the electrophoresis deposition method is used second and subsequent times.

19. The piezoelectric/electrostrictive film type actuator according to claim 13, wherein two or three green sheets in each of which at least one hole portion is formed are laminated.

20. The piezoelectric/electrostrictive film type actuator according to any one of claims 13 to 19, which is used as an ink pump of a printer head disposed in an ink jet printer.

21. A manufacturing method of a piezoelectric/

electrostrictive film type actuator which comprises a ceramic substrate and a piezoelectric/electrostrictive device disposed on the ceramic substrate and including a piezoelectric/electrostrictive film and electrode film, and said substrate being provided with a cavity being formed in an internal portion thereof and said cavity being pressurized by deforming a part of a wall of the cavity with the piezoelectric/electrostrictive device,

characterized in that the method comprises:

a step A of preparing a green sheet laminate including at least one green sheet which is a substrate and at least one green sheet in which at least one hole portion is formed and sintering the green sheet laminate to obtain a ceramic laminate;

a step B of forming an electrode film (A) in the outer surface of the obtained ceramic laminate by a film forming method;

a step C of forming a piezoelectric/electrostrictive film (A) on the electrode film (A) by the film forming method; and a step D of further forming an electrode film (B) on the piezoelectric/electrostrictive film (A) by the film forming method to repeat the steps C and D once or a plurality of times; and

a step E of thereafter forming a piezoelectric/electrostrictive film (B) on the electrode film (B) by the film forming method; and further a step F of forming an electrode film (C) on the piezoelectric/electrostrictive film

(B) by the film forming method,

wherein sintering of the piezoelectric/ electrostrictive film and/or the electrode film is performed predetermined times at an arbitrary timing during a period after the electrode film (A) is formed until the electrode film (C) is formed.

22. The manufacturing method of the piezoelectric/ electrostrictive film type actuator according to claim 21, wherein a thickness t_n of the piezoelectric/electrostrictive film formed n-th time satisfies the following equation:

$$t_n \leq t_{n-1} \times 0.95.$$

23. The manufacturing method of the piezoelectric/ electrostrictive film type actuator according to claim 21 or 22, wherein in the steps of forming and sintering the electrode film (B) at a sintering temperature Tm1 (°C) and forming and sintering the piezoelectric/ electrostrictive film (B) at a sintering temperature Tm2 (°C), the following equation is satisfied:

$$0 \leq Tm2 - Tm1 \leq 300.$$

24. The manufacturing method of the piezoelectric/ electrostrictive film type actuator according to any one of claims 21 to 23, further comprising the steps of: subjecting the piezoelectric/electrostrictive film and electrode film to a plurality of film forming methods per layer to form the films.

25. The manufacturing method of the piezoelectric/ electrostrictive film type actuator according to any one of

claims 21 to 24, wherein at least one thick film forming method selected from a group consisting of a screen printing method, dipping method, coating method, and electrophoresis deposition method is used as the film forming method.

26. The manufacturing method of the piezoelectric/electrostrictive film type actuator according to any one of claims 21 to 24, wherein as the film forming method of the piezoelectric/electrostrictive film, the screen printing method is used first time and the electrophoresis deposition method is used second and subsequent times.

27. The manufacturing method of the piezoelectric/electrostrictive film type actuator according to claim 21, wherein the step A includes a step of preparing one or a plurality of laminated green sheets which form the substrate and in each of which at least one hole portion is formed.

28. The manufacturing method of the piezoelectric/electrostrictive film type actuator according to claim 27, further comprising the steps of: laminating two or three green sheets in each of which at least one hole portion is formed.

29. The manufacturing method of the piezoelectric/electrostrictive film type actuator according to any one of claims 21 to 28, wherein the actuator is used as an ink pump of a printer head disposed in an ink jet printer.